

DINOSAUR BONE BEDS AND MASS MORTALITY: IMPLICATIONS FOR THE K-T EXTINCTION

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Mass accumulations of fossilized large terrestrial vertebrate skeletons (bone beds: BB) provide a test for K-T catastrophic extinction hypotheses.

The two major factors contributing to BB formation are mode of death and sedimentation rate. Catastrophic mass mortality (CMM) is the "sudden" (< hour) death of numerous individuals where species, age, health, gender, social ranking, etc., offer no survivorship advantage (eg. death of 1,700 villagers and 3,000 cattle by a gas cloud in Cameroon [1]). Noncatastrophic mass mortality (NCMM) occurs over time (> hour) and is strongly influenced by species, age, gender, etc. (eg. drought [2]). Such mortality occurs at a level greater than attritional mortality (AM) due to old age, predation, etc.

In addition to cause of death, sedimentation rate is also important in BB formation. Low sedimentation rates (including dry season nonsedimentation) permit scavenging, decomposition and bone weathering, hence disarticulation is high. An exception is mummification, which can result in articulated specimens [3]. High sedimentation retards scavenging and decomposition resulting in more articulated skeletons.

From the above, models of BB's can be made. CMM drops all individuals in their tracks, therefore, the BB should reflect the living population with respect to species, age, gender, etc. Articulation may be complete if burial is also the killing agent (eg. mudslides). If burial is delayed, disarticulation and bone weathering may be high (see ref. 4 for qualifiers). Regardless, most skeletons and bones should show the same degree of articulation and weathering. NCMM results in monospecific BB's skewed in the direction of the less fit, usually the very young or very old, or towards a specific gender [2]. Because death occurs over time, skeletons may show a wide range of articulation and bone weathering. An AM BB should also be biased towards the very young or very old, but should not be gender specific. Bones are usually not articulated and may show a wide range of weathering. NCMM and AM BB's may become more similar the more spread out over time NCMM deaths occur because 1) carcasses are widely scattered (eg. ref. 2) requiring hydraulic accumulation, and 2) the greater time allows for more disarticulation and weathering. Mixing of mortality types in a BB complicates interpretation.

The best example of a CMM BB is an ashfall burial of Miocene (10 mya) vertebrates in Nebraska [5]. Birds, horses, and camels at the base of the ash bed suggest immediate death by the ashfall. Rhinoceroses occur higher in the ash suggesting a later death. However, grass seeds in some throats suggests the animals had been feeding, hence death must have been rapid for them as well.

An example of an NCMM BB is the Iguanodon skeletons recovered from a coal mine in the Wealden (Lower Cretaceous) of Bernissart, Belgium. Specimens consist of partial to complete skeletons, and isolated limbs and single bones. Current orientation [6] suggests that water accumulated the carcasses. Dominance by a single gender may explain why the more robust Iguanodon bernissartensis (N=24) is more common than the gracile I. mantelli (N=1). It remains to be proven, however, that these species are different gender morphs of the same species.

An example of an AM BB is the Revuelto Creek Quarry in the Dockum Formation (Upper Triassic) of New Mexico [7]. Taxa diversity is high (N=7), although most are represented by a few bones. Taxa include fish, and various reptiles, including a dinosaur. Unlike the CMM and NCMM BB, no single taxon dominates.

CMM and NCMM BB appear to be dominated by social animals, which many dinosaurs seem to have been. Applying this and the above characteristics of mortality patterns to the uppermost Cretaceous Hell Creek Formation indicates that only NCMM (eg. hadrosaur or ceratopsian) and AM BB occur. Furthermore, NCMM BB are rare in the upper third of the Hell Creek. Near the K-T boundary, only AM BB are known. The absence of CMM and NCMM BB appears to be real reflecting a decrease in population levels of some dinosaurs prior to the K-T "event" [8]. The absence of CMM suggests that the K-T "event" did not lead to an instantaneous extinction of dinosaurs. Nor was there a protracted die-off due to an asteroid impact winter, because no NCMM BB are known at or near the K-T boundary. AM BB neither support nor refute an asteroid impact 65 mya.

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